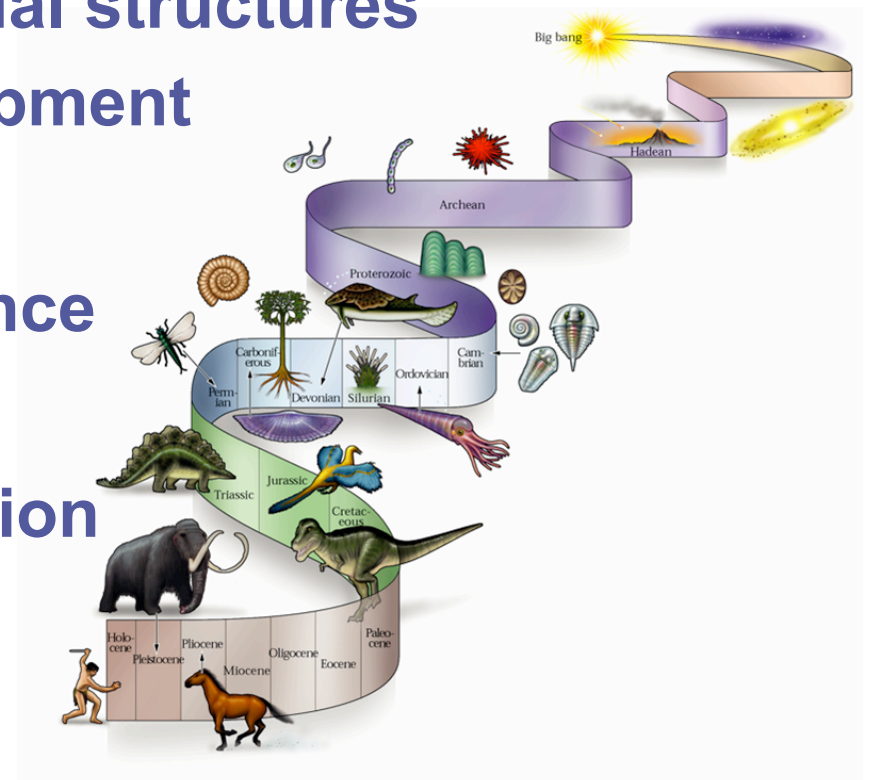


Evidence of Evolution by Natural Selection



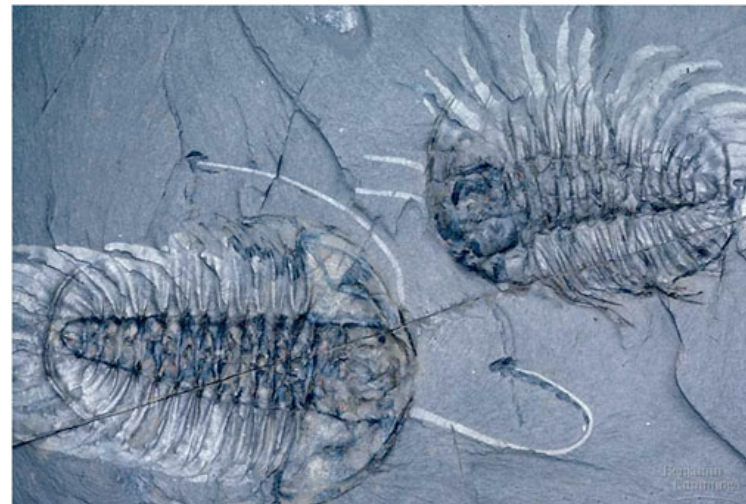
Evidence supporting evolution

- **Fossil record**
 - ◆ transition species
- **Anatomical record**
 - ◆ homologous & vestigial structures
 - ◆ embryology & development
- **Molecular record**
 - ◆ protein & DNA sequence
- **Artificial selection**
 - ◆ human-caused evolution



Fossil record

- **Layers of sedimentary rock contain fossils**
 - ◆ new layers cover older ones, creating a record over time
 - ◆ fossils within layers show that a succession of organisms have populated Earth throughout a long period of time

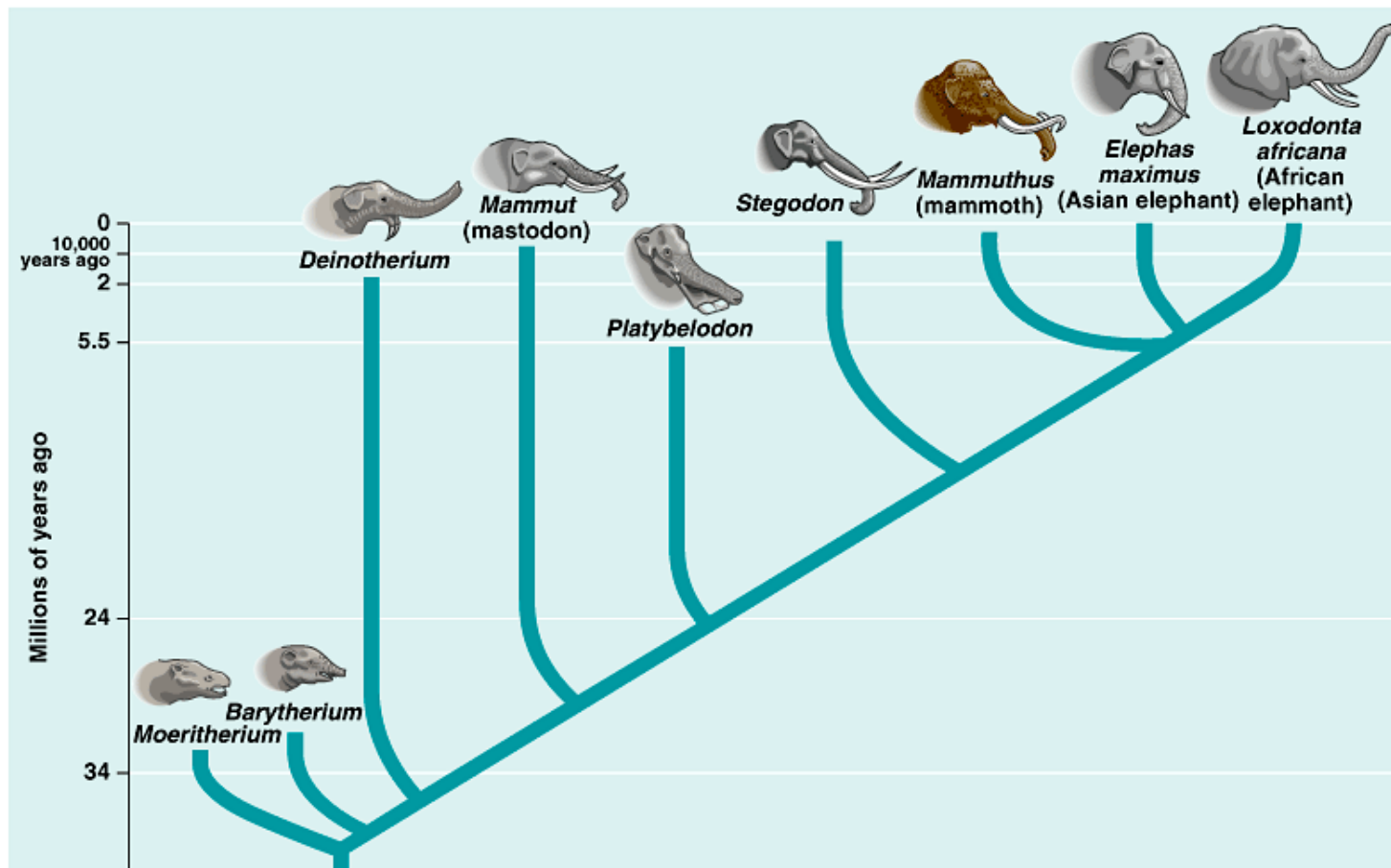


Fossil Record

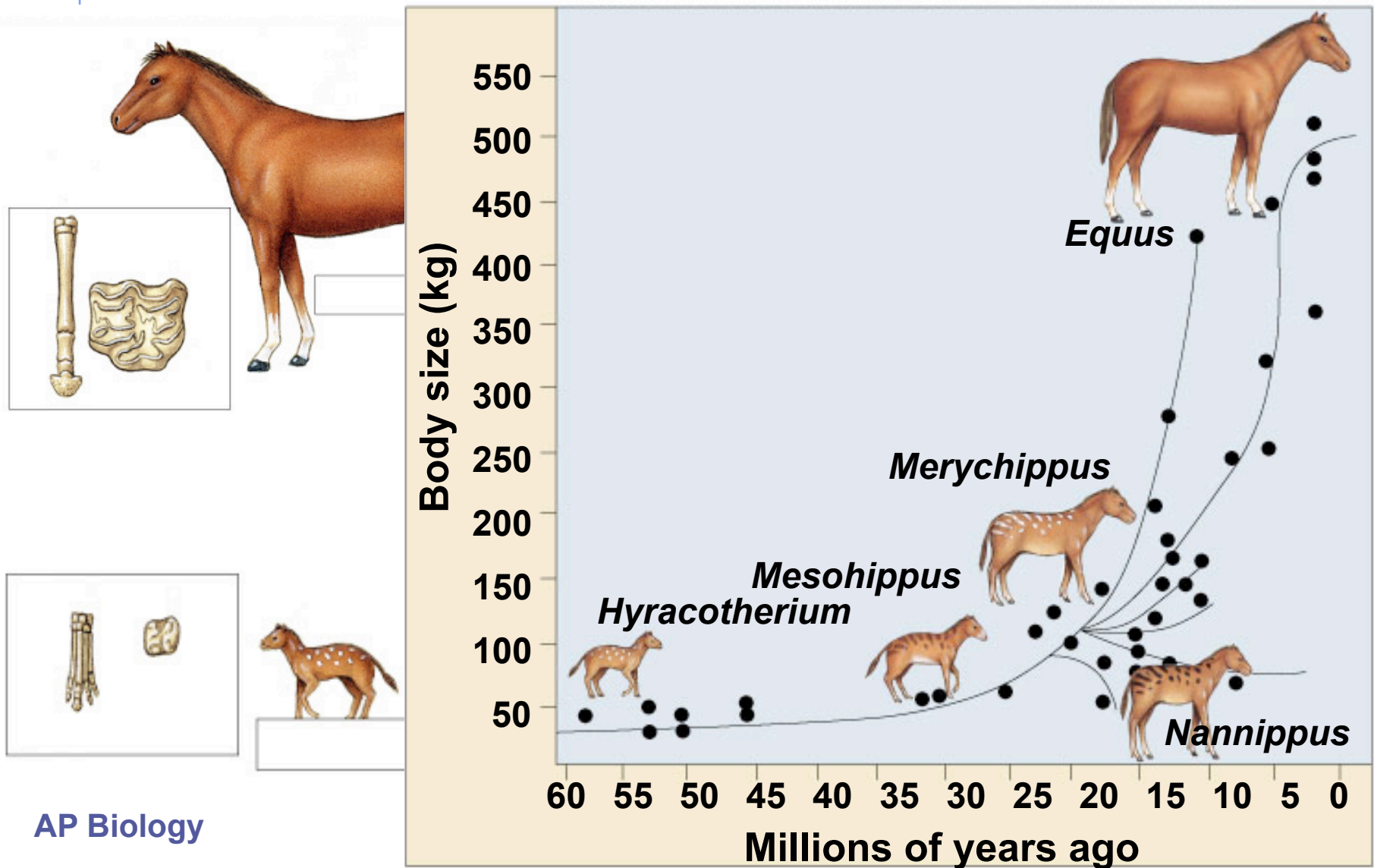


Fossil record

- A record showing us that today's organisms descended from ancestral species



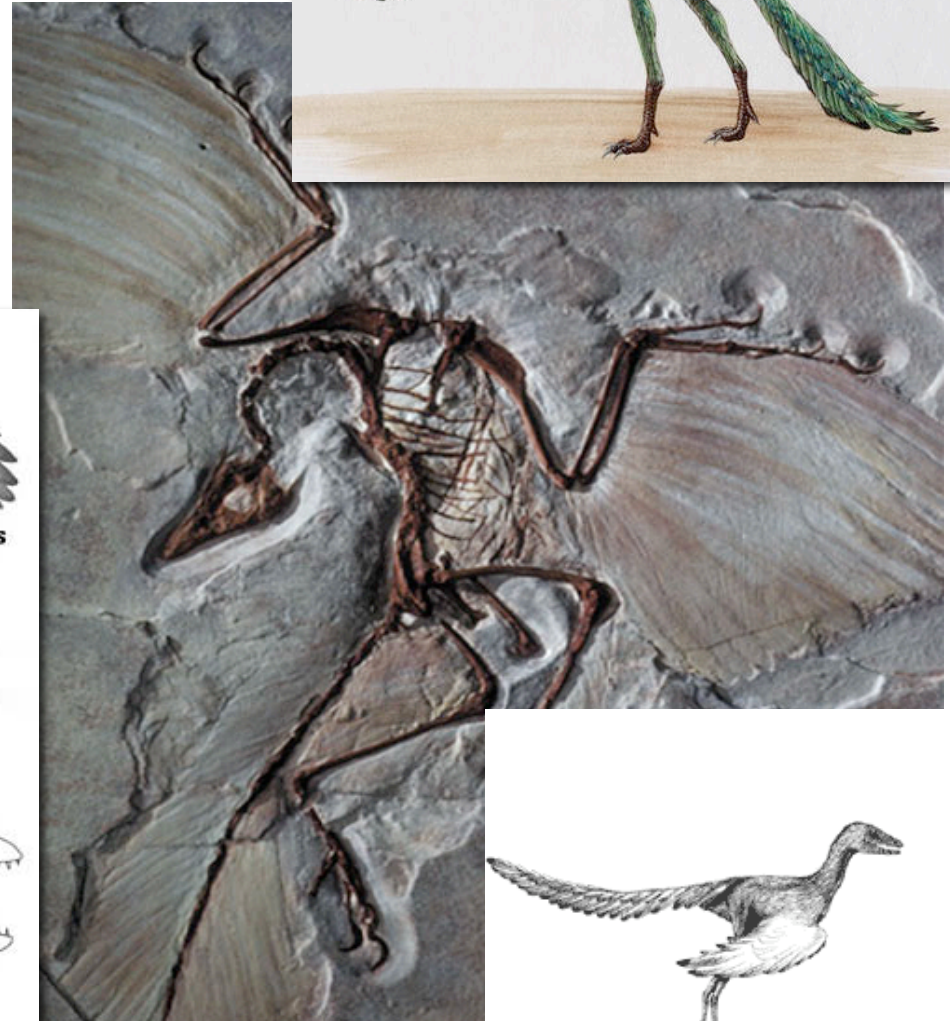
Evolutionary change in horses



Evolution of birds

■ *Archaeopteryx*

- ◆ lived about 150 mya
- ◆ links reptiles & birds



Theory takes flight

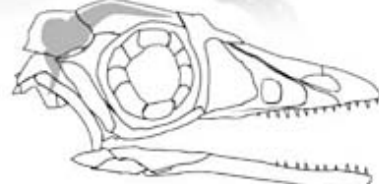
A computer analysis of skull specimens from the bird-like dinosaur archaeopteryx indicates the creature was a skillful flier, according to a study in the journal Nature.

Wingspan: **19.6 inches**
Weight: **12 ounces**

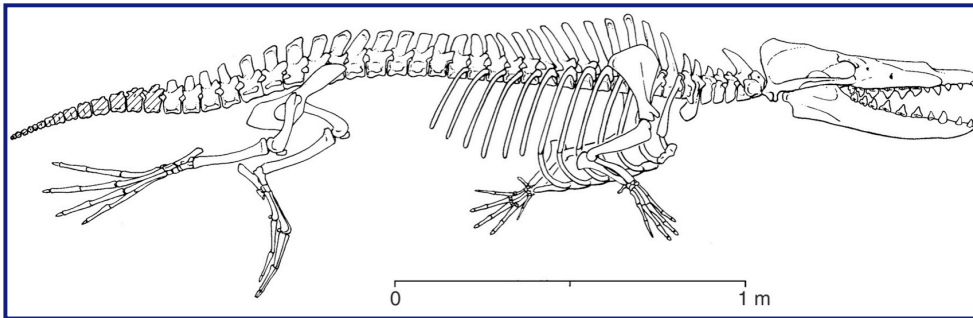
Brain

Modern flying bird

archaeopteryx



► The scientists point to similarities in the brain lobes responsible for vision, balance and flight coordination.



65 60 55 50 45 40 35 30 million years ago

Paleocene

Eocene

Oligocene



Land Mammal

?

?

Where are the
transitional
fossils?

?

?

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Evolution: The Triumph of an Idea,
by Carl Zimmer.
New York: Harper Collins Publishers, 2001.
Source: Art by Deborah Perugi,
adapted from Carl Buell's
cladogram from *At the Water's Edge*,
by Carl Zimmer, Free Press, 1998.
file source:

Cetacean Evolution (Whales, Porpoises, Dolphins)
by Edward T. Babinski
http://www.edwardtbabinski.us/babinski/whale_evolution.html



Basilosaurus

Mysticetes



Odontocetes

2006 Fossil Discovery of Early Tetrapod

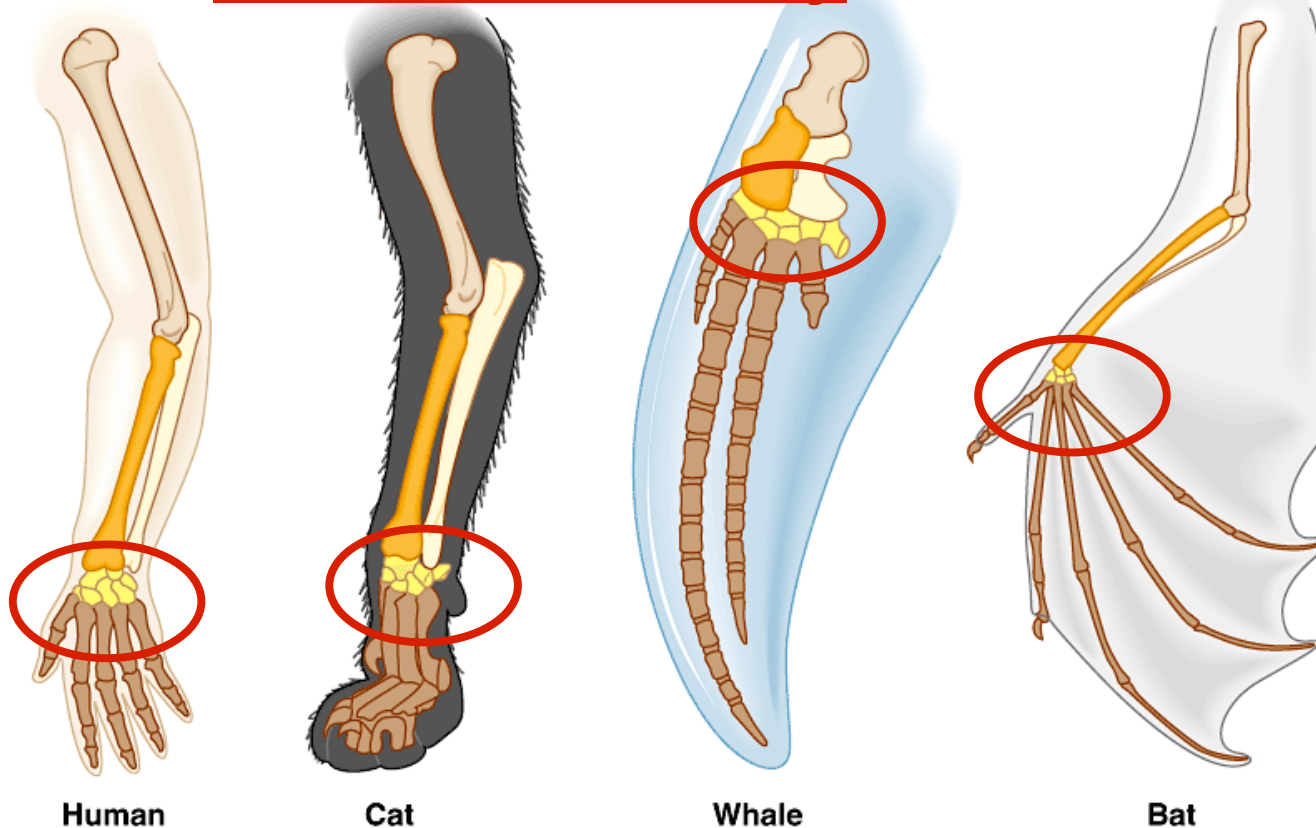
- **Tiktaalik**

- ◆ “missing link” from sea to land animals



Anatomical record

- Homologous structures
 - ◆ similarities in characteristics resulting from common ancestry



Homologous structures

- Similar structure
- Similar development
- Different functions
- Evidence of close evolutionary relationship
 - ◆ recent common ancestor



Homologous structures

spines



leaves



succulent leaves



needles



tendrils



colored leaves

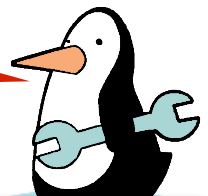


Analogous structures

- Separate evolution of structures
 - ◆ similar functions
 - ◆ similar external form
 - ◆ different internal structure & development
 - ◆ different origin
 - ◆ **no evolutionary relationship**



Don't be fooled
by their looks!



Solving a similar problem with a similar solution

Convergent evolution

- Flight evolved in 3 separate animal groups
 - ◆ evolved similar “solution” to similar “problems”
 - ◆ analogous structures

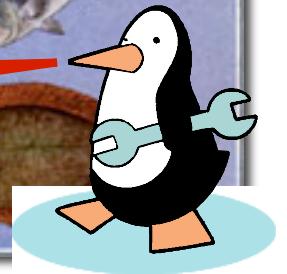


Convergent evolution

- Fish: aquatic vertebrates
- Dolphins: aquatic mammals
 - ◆ similar adaptations to life in the sea
 - ◆ not closely related



Those fins & tails
& sleek bodies are
analogous structures!



Parallel Evolution



- **Convergent evolution in common niches**
 - ◆ filling similar ecological roles in similar environments, so similar adaptations were selected
 - ◆ but are not closely related

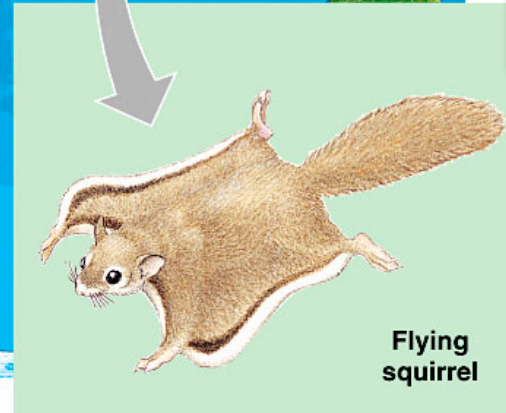
**marsupial
mammals**



**NORTH
AMERICA**

















**placental
mammals**



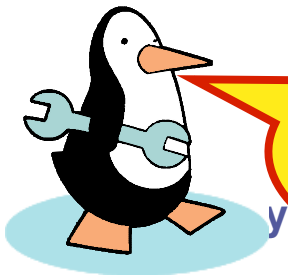
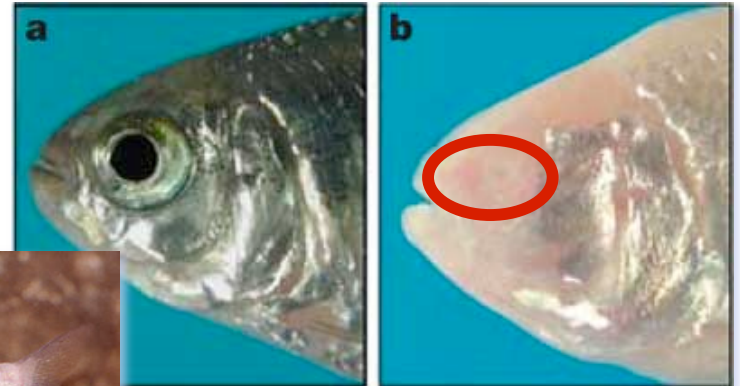
Parallel types across continents



| Niche | Placental Mammals | Australian Marsupials |
|-----------------------|---|--|
| Burrower |  Mole |  Marsupial mole |
| Anteater |  Anteater |  Numbat |
| Nocturnal insectivore |  Mouse |  Marsupial mouse |
| Climber |  Lemur |  Spotted cuscus |
| Glider |  Flying squirrel |  Sugar glider |
| Stalking predator |  Ocelot |  Tasmanian cat |
| Chasing predator |  Wolf |  Tasmanian "wolf" |

Vestigial organs

- Modern animals may have structures that serve little or no function
 - ◆ remnants of structures that were functional in ancestral species
 - ◆ deleterious mutations accumulate in genes for non-critical structures *without* reducing fitness
 - snakes & whales — remains of pelvis & leg bones of walking ancestors
 - eyes on blind cave fish
 - human tail bone



This is not
LaMarck's loss
from "disuse"!

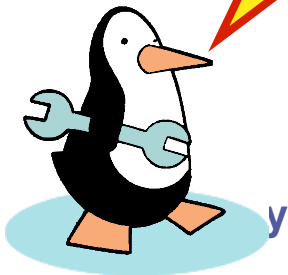


Vestigial organs

- Hind leg bones on whale fossils

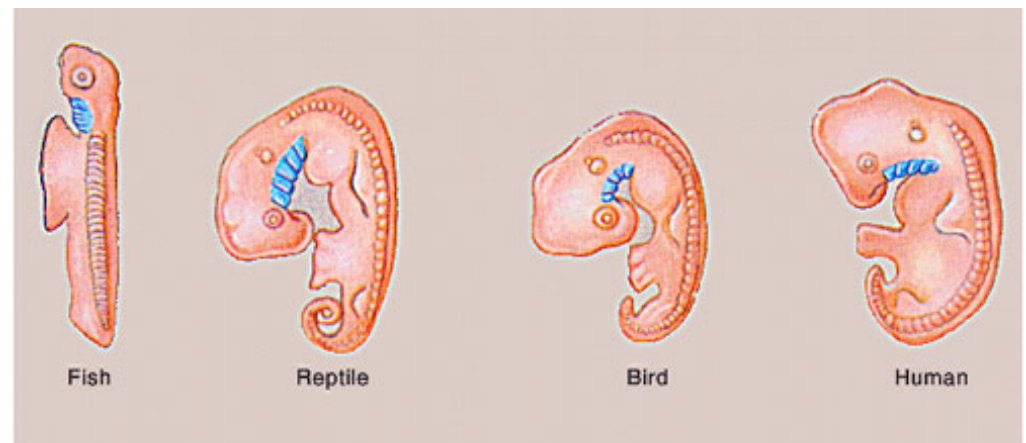
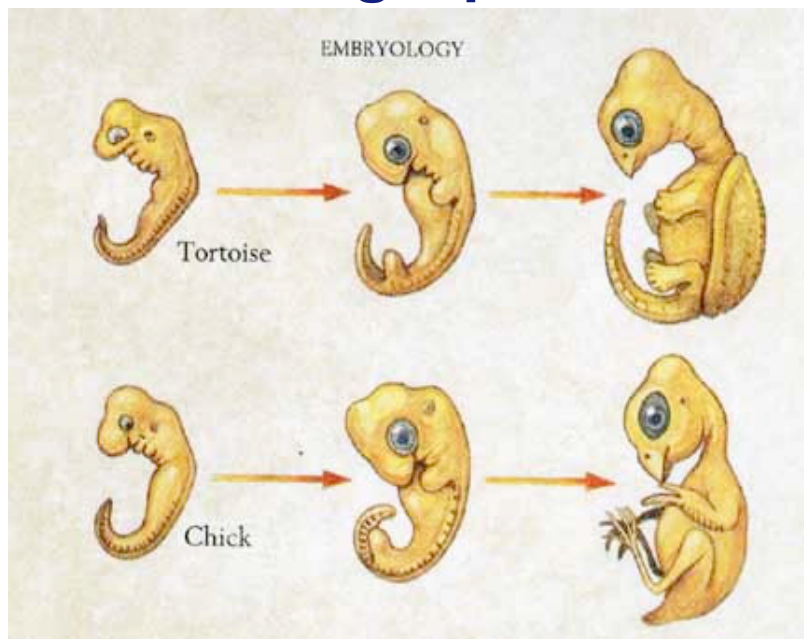


Why would whales have pelvis & leg bones if they were always sea creatures?



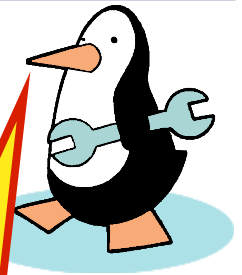
Comparative embryology

- Similar embryological development in closely related species
 - ◆ all vertebrate embryos have similar structures at different stages of development
 - gill pouch in fish, frog, snake, birds, human, etc.



Molecular record

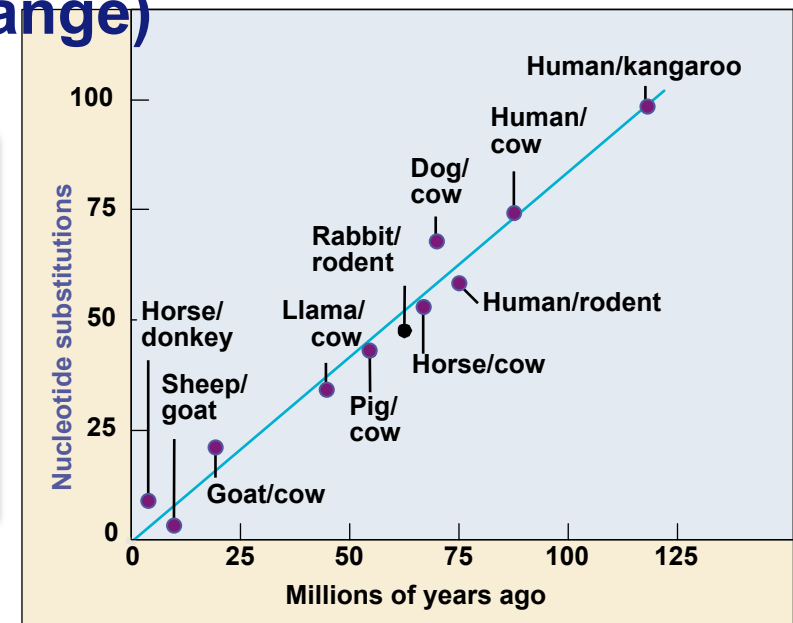
- Comparing DNA & protein structure
 - ◆ universal genetic code!
 - DNA & RNA
 - ◆ compare common genes
 - cytochrome C (respiration)
 - hemoglobin (gas exchange)



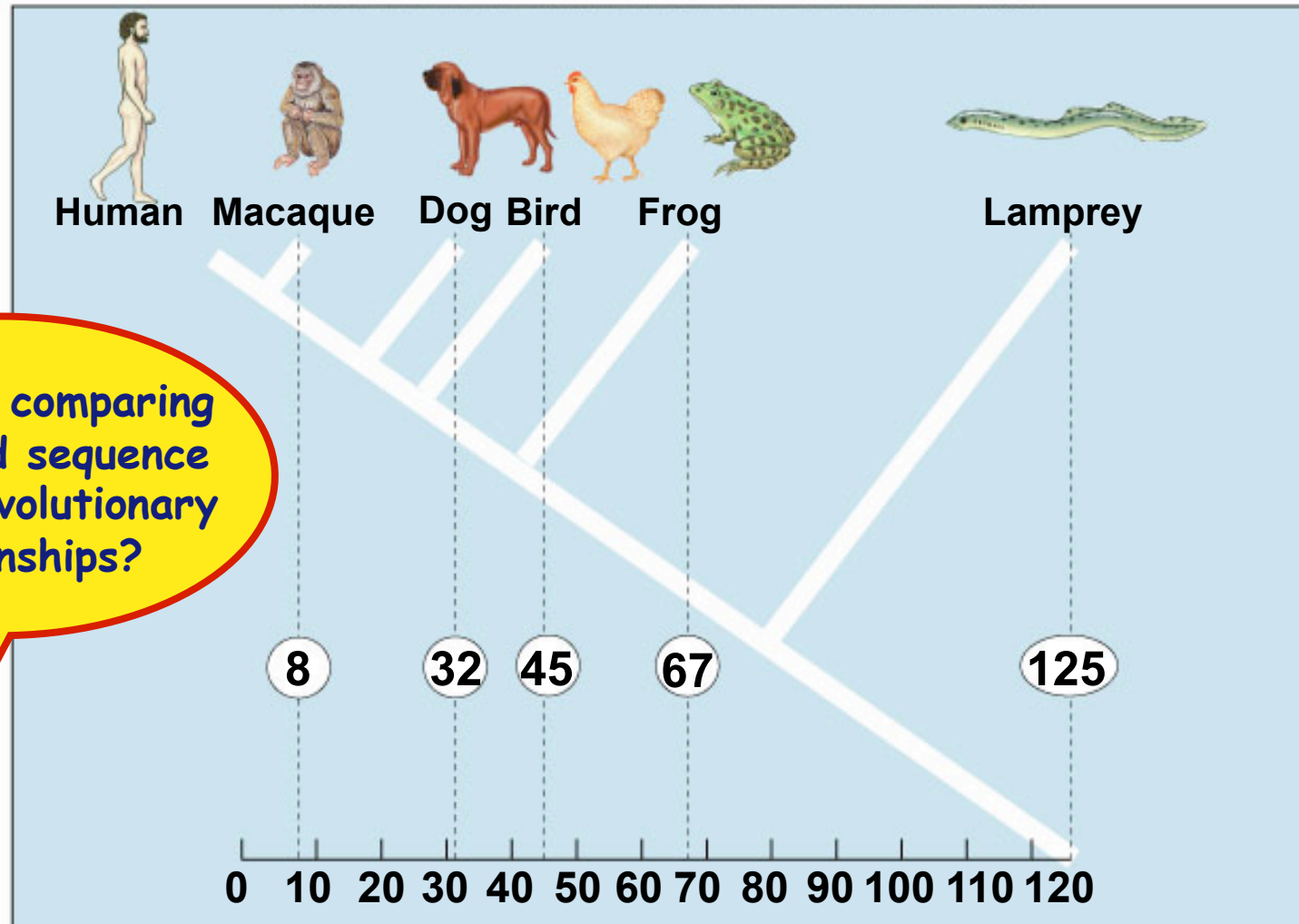
Why compare these genes?

Closely related species have sequences that are more similar than distantly related species

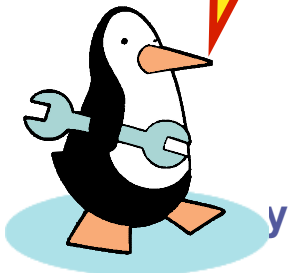
- DNA & proteins are a molecular record of evolutionary relationships



Comparative hemoglobin structure



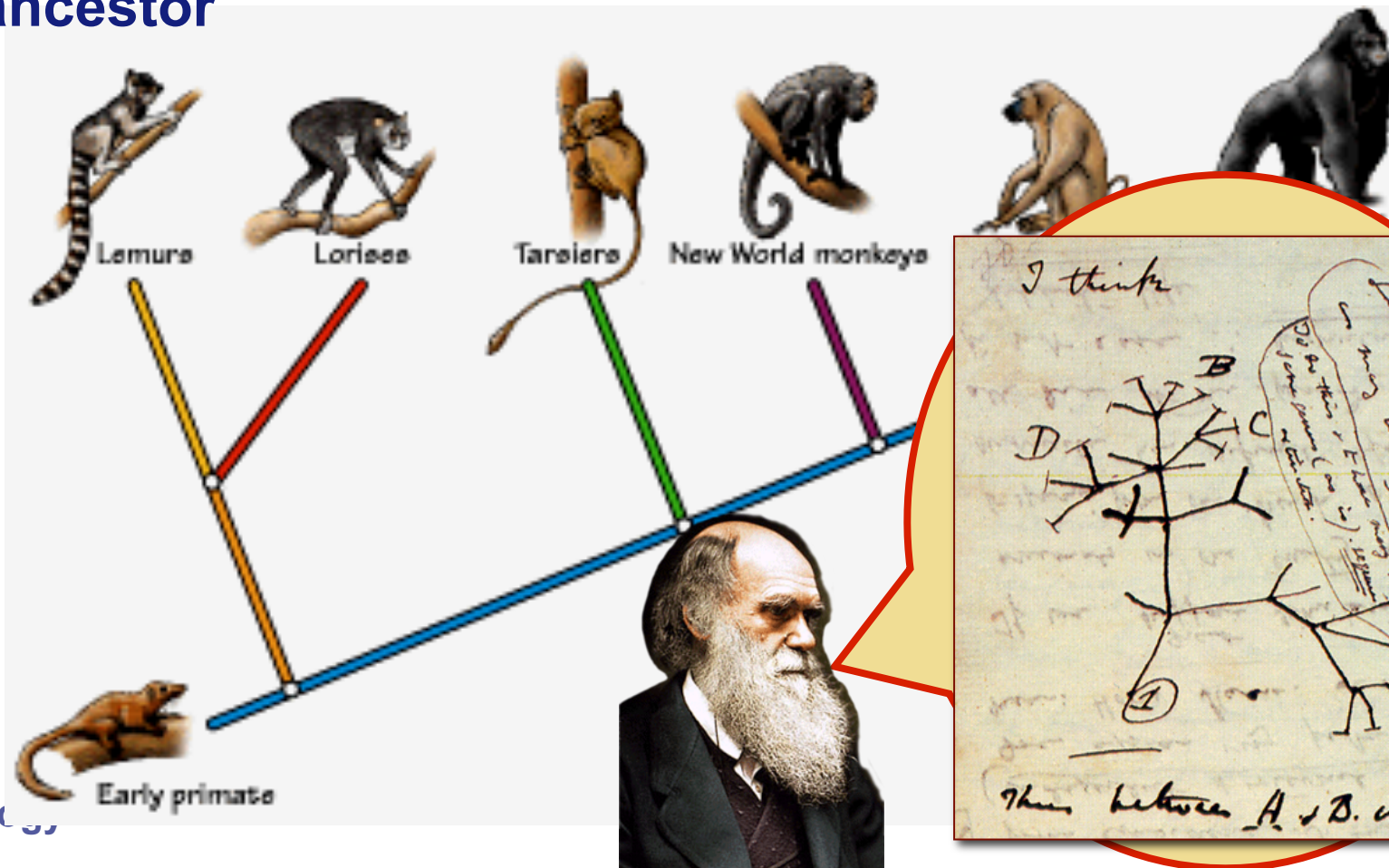
Why does comparing amino acid sequence measure evolutionary relationships?



Number of amino acid differences between hemoglobin (146 aa) of vertebrate species and that of humans

Building “family” trees

Closely related species (branches) share same line of descent until their divergence from a common ancestor



Artificial selection

- Artificial breeding can use variations in populations to create vastly different “breeds” & “varieties”



“descendants” of wild mustard

“descendants” of the wolf

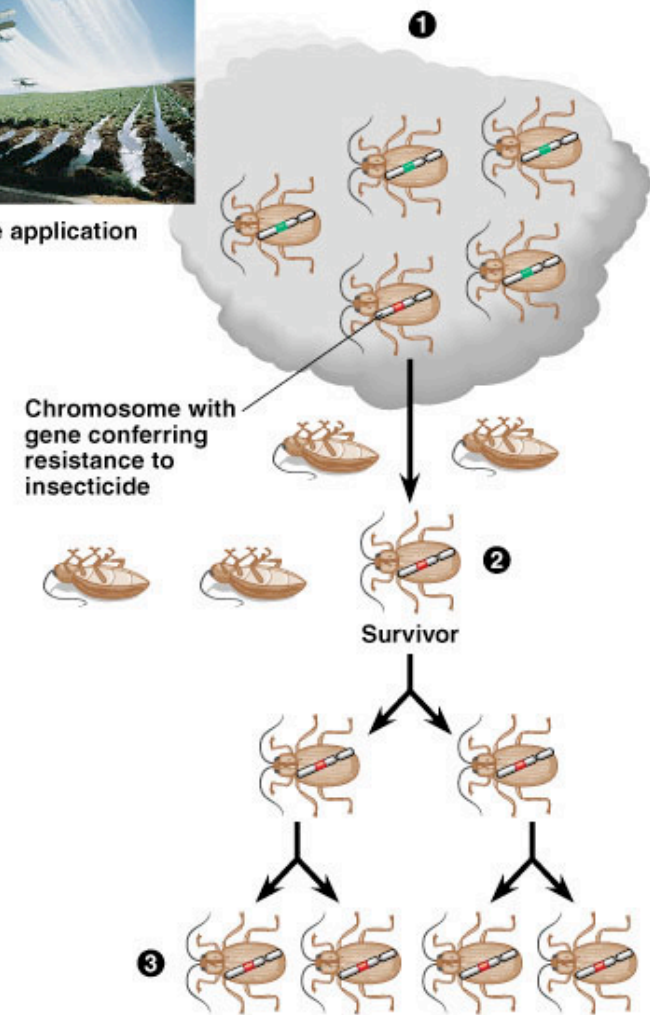


Natural selection in action

- Insecticide & drug resistance
 - ◆ insecticide didn't kill all individuals
 - ◆ resistant survivors reproduce
 - ◆ resistance is inherited
 - ◆ insecticide becomes less & less effective



Insecticide application





Evolution is "so overwhelmingly established that it has become irrational to call it a theory."



-- Ernst Mayr
What Evolution Is

2001

Professor Emeritus, Evolutionary Biology
Harvard University
(1904-2005)

2007-2008

Don't be a Dodo...
Ask Questions!!

